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An analysis of the variables that influence a country's decision to ratify the Stockholm Convention on Persistent Organic Pollutants

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AN ANALYSIS OF THE VARIABLES THAT INFLUENCE A COUNTRY'S DECISION TO RATIFY THE STOCKHOLM CONVENTION ON PERSISTENT ORGANIC POLLUTANTS

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ABSTRACT

The objective of this thesis is to identify key factors that influence a country to ratify the Persistent Organic Pollutants (POPs) Treaty. The POPs treaty seeks to eliminate or reduce the emissions of 12 POPs. I will examine the links between the countries that have ratified the POPs treaty in an effort to identify variables that may have influenced a country's decision to ratify the treaty. For each of the 165 nations in my dataset, I will examine economic, social, geographic, health, and political indicators and history of malaria and determine if a relationship exists between these variables and treaty ratification.

Results indicate that a history of malaria, political, economic, and geographic indicators are significantly related to a nation's decision to ratify the treaty. Specifically, level of democracy, history of malaria, and location in Asia are deemed to be significantly correlated with treaty ratification, while location in Oceania and GDP per capita are regarded as extremely significantly correlated to treaty ratification. Of these five variables, only a history of malaria is inversely related to treaty ratification. This finding suggests that countries with a history of malaria are less likely to ratify the POPs treaty than countries that do not have a history of malaria. The remaining four variables are positively related to treaty ratification which suggests that as GDP per capita or level of democracy increases, the tendency of a nation to ratify the treaty also increases. Location in Oceania and Asia also tend to influences a nation's decision to ratify the treaty.

CHAPTER 1. INTRODUCTION

The international treaty on persistent organic pollutants was signed on May 31, 2001 in Stockholm, Sweden by 151 countries. The Stockholm Convention seeks the elimination or restricted use of twelve persistent organic pollutants (POPs). The POPS slated to be banned are aldrin, chlordane, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, toxaphene, and polychlorinated biphenyls (PCBs), while dichlorodiphenyl-dichloroethane (DDT) will still be used in disease vector control. Furans and dioxins are byproducts of incomplete combustion of fossil fuels, and thus the goal is to reduce the emission of these chemicals. While these two chemicals cannot be banned, their emissions can be reduced by changing industrial practices. While the POPs treaty was signed in May of 2001, it did not take effect until May 17, 2004, 90 days after being ratified by a fiftieth country. As of November 2004, the Persistent Organic Pollutant (POPs) treaty has been ratified by 90 parties (table 1)[1].

Persistent organic pollutants are a class of chemicals that bioaccumulate in human tissue and animal tissue. They are also persistent in the environment. Persistent organic pollutants have numerous negative effects on the human health and environment. The dioxin-like PCB is known as an anti-estrogen due to the way it inhibits estrogen-induced responses[2]. Prenatal exposure to the PCBs has been linked to a delay in cognitive development[3], increased rates of middle ear infections, and more behavioral problems in exposed children than in unexposed children[4]. Hexachlorobenzene and mirex cause liver cancer and affect the nervous and reproductive system[5.] Aldrin and dieldrin cause pregnant animals to have low-birth weight babies with alterations in their skeletons[5]. The evidence also suggests that prenatal exposure to POPs causes the fetus to be especially

Table 1: A Listing of the Ratifying Parties to the Stockholm Treaty.

Albania	France	Philippines
Antigua and Barbuda	Germany	Portugal
Armenia	Ghana	Qatar
Australia	Iceland	Republic of Moldova
Austria	Japan	Romania
Azerbaijan	Jordan	Rwanda
Barbados	Kenya	Saint Kitts and Nevis
Belarus	Kiribati	Saint Lucia
Benin	Latvia	Samoa
Bolivia	Lebanon	Senegal
Botswana	Lesotho	Sierra Leone
Brazil	Liberia	Slovakia
Bulgaria	Liechtenstein	Slovenia
Burkina Faso	Luxembourg	Solomon Islands
Canada	Mali	South Africa
Chad	Marshall Islands	Spain
China	Mauritius	Sweden
Cook Islands	Mexico	Switzerland
Côte d'Ivoire	Monaco	The Former Yugoslav Republic of Macedonia
Czech Republic	Mongolia	Togo
Democratic People's Republic of Korea	Morocco	Trinidad and Tobago
Denmark	Myanmar	Tunisia
Djibouti	Nauru	Tuvalu
Dominica	Netherlands	Uganda
Ecuador	New Zealand	United Arab Emirates
Egypt	Nigeria	United Kingdom of Great Britain and Northern Ireland
Ethiopia	Norway	United Republic of Tanzania
European Community	Panama	Uruguay
Fiji	Papua New Guinea	Viet Nam
Finland	Paraguay	Yemen

sensitive to such chemicals[4]. Postnatal exposure of POPs also impacts the health of animals. Adult males who are exposed to PCBs are shown to have a decrease in sperm motility[6]. Also, dioxins and furans are human carcinogens. Rats and mice that were exposed to small amounts of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) developed liver and thyroid cancer[5].

Even though DDT is a persistent organic pollutant, it has long been used as a major component of malaria prevention programs across the globe. While the Stockholm Convention does allow for the use of DDT in such programs, it puts forth restrictions on the use of DDT. DDT use is restricted to disease vector control. Since DDT is not the only effective means of combating malaria, the Parties of the Convention also encourage the "implementation of suitable alternative products, methods and strategies, including resistance management strategies to ensure the continuing effectiveness of these alternatives"[7]. A third measure seeks to strengthen health care in malaria stricken areas in an effort to reduce incidence of the disease. The "long-term objective of the Stockholm Convention is the development of safe, effective and affordable [alternatives], which could effectively replace the use of DDT"[8]. However, there is no set deadline for when DDT should be phased out. Malaria-stricken nations will be able to use DDT for as long as they deem necessary.

Research Objectives

The objective of this thesis is to identify key factors that influence a country to ratify this type of treaty. Specifically, I will examine the links between the countries that have ratified the POPs treaty in an effort to identify variables that may have influenced a country's decision to ratify the treaty. For each of the 165 nations in my dataset, I will be examining economic indicators such as gross domestic product (GDP), annual population growth rate, public health expenditure as a percent of GDP, and distribution of total output of goods and services into the agricultural, industrial, and service sectors. Also, I will examine social indicators such as population density, fertility rate, under five mortality rate, life expectancy, adult literacy, and history of malaria. Then, I will compare these values with world averages to answer a set of research questions. Are nations that ratify the POPs treaty richer than average? Is education related to treaty ratification? Are countries that place large amounts of money into their public health care systems more willing to ratify the POPs treaty? Are malaria-stricken countries more willing to ratify the POPs treaty than countries that are not affected by malaria?

These findings will shed light on the factors that make nations enter voluntary international environmental agreements. As nations struggle with complex environmental issues, international treaties will take on greater importance to address a variety of global challenges. Greater nation participation in international environmental agreements will be necessary in order to prevent greater degradation of the environment. The following chapter will present an overview of the Stockholm Convention.

CHAPTER 2. THE STOCKHOLM CONVENTION

Overview

The United Nations Conference on Environment and Development (Earth Summit), held in Rio de Janeiro in 1992, and Agenda 21 laid the foundation for the Stockholm Convention on Persistent Pollutants. Chapter 17 of Agenda 21 concerns the protection of the oceans from toxic polluting chemicals that are persistent and bioaccumulate in the food chain[9]. Chapter 19 of Agenda 21 seeks to "ensure the environmentally sound management of toxic chemicals"[10]. The precautionary principle, which is in Principle 15 of the Rio Declaration on Environment and Development, states that "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation"[11].

The United Nations Environment Program (UNEP) asked the International Programme on Chemical Safety (IPCS) and the Intergovernmental Forum on Chemical Safety (IFCS) to create an ad hoc group to generate a list of potential POPs. The aim of the group was to examine the sources, risks, benefits, production, and use of the POPs. In addition, the group evaluated substitutes by determining their availability, costs, and efficacy. UNEP received an initial list of twelve persistent organic pollutants in 1997 and then requested that an intergovernmental negotiating committee (INC) prepare a binding document for implementing international action against the twelve POPs. Five negotiating sessions were held over the next 3 years in Montreal, Nairobi, Geneva, Bonn, and South Africa. On May 21, 2001, six months after the final meeting in South Africa, the Stockholm Convention on Persistent Organic Pollutants opened for signature.

The objective of the Stockholm Convention is to protect the human health and the environment from persistent organic pollutants. The Convention is a legally binding instrument that seeks to eliminate or reduce 12 persistent organic pollutants. The pollutants are grouped into three categories: pesticides (aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex, and toxaphene), industrial chemicals (hexachlorobenzene and PCBs), and unintended byproducts (dioxins and furans). The chemicals are divided into Annexes A, B, and C. Annex A chemicals are to be eliminated, Annex B chemicals are to be restricted, and Annex C chemicals are to be reduced as they are produced unintentionally. The Annex A chemicals are aldrin, chlordane, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, toxaphene, and PCBs. DDT is the only Annex B chemical, while furan, dioxin, hexachlorobenzene, and PCBs are the Annex C chemicals. Hexachlorobenzene and PCBs are both Annex A and Annex C chemicals because they can be manufactured or they can be created from thermal processes involving chlorine and organic matter.

Origin and Health Risks of Chemicals Listed in the Convention.

The Annex A chemicals are being eliminated due to their potentially harmful effects on the human health and environment. Aldrin and dieldrin are pesticides with similar chemical structures, and from the 1950s until 1970, both chemicals were used as pesticides for crops such as corn and cotton. In 1974, the EPA banned the use of either chemical except to control termites, but in 1987, the agency banned all uses of the chemicals. Aldrin and dieldrin have been shown to cause liver cancer in mice and are deemed probable human carcinogens[5]. People exposed to moderate levels of aldrin and dieldrin have headaches, dizziness, irritability, nausea, and uncontrollable muscle spasms[5].

From 1948 to 1983, chlordane was used as a pesticide on crops like corn and citrus and on home lawns and gardens. In 1983, the EPA restricted its use to termite control, and then, in 1988, banned all uses. Mice exposed to chlordane developed liver cancer, but the International Agency for Research on Cancer (IARC) has determined that chlordane cannot be classified as to its human carcinogenicity[12]. Chlordane affects the nervous system, digestive system, and liver of exposed persons. People who breathe in contaminated air suffer from headaches, irritability, confusion, muscle weakness, jaundice, and vision problems[5].

Endrin had been used as a pesticide to control insects, birds, and rodents, but has not been produced or used in the US since 1986. The EPA has determined that endrin cannot be classified as to its human carcinogenicity due to insufficient data[12]. However, people exposed to endrin can suffer from severe central nervous system injury. In addition, endrin poisoning causes headaches, dizziness, confusion, nausea, and convulsions[5].

Heptachlor was used as both an insecticide and a pesticide on food crops such as corn, but has not been used in the US since 1988. Heptachlor cannot be classified as to its human carcinogenicity due to insufficient data[12]. Mice and rats exposed to heptachlor had trouble walking and developed tremors. People who are exposed to the chemical have damaged nervous systems and become dizzy and confused[5].

Hexachlorobenzene was used as a pesticide for crops such as wheat and sorghum and was used to make fireworks, ammunition, and synthetic rubber. However, the chemical is no longer in use or being produced in the US. Hexachlorobenzene is a possible human carcinogen[12]. Animals exposed to the chemical for long periods developed liver, kidney, and thyroid cancer. People in Turkey who were accidentally exposed to the chemical in their food developed the liver disease porphyria cutanea tarda, which caused red-colored urine, skin sores, skin discoloration, and arthritis[5].

From 1959 to 1972, mirex was used to control fire ants and as a flame retardant, but it has not been used or produced in this country since 1978. Mirex has been labeled as being reasonably anticipated to be a carcinogen[12]. Animals that ingest mirex developed liver, adrenal gland, and kidney tumors. Mirex also affects female animals' ability to reproduce. People who are exposed to mirex had harmful effects on the skin, liver, nervous system, and male reproductive system[5].

Toxapehene is an insecticide containing over 670 chemicals. It was primarily used in the southern United States to control pests on cotton crops and on livestock. In addition, toxaphene killed unwanted fish in lakes. Animals exposed to toxaphene over an extended period of time developed thyroid cancer, and the chemical has been determined to reasonably be anticipated to cause cancer in humans[12]. Exposure to toxaphene damages the lungs, kidneys, and nervous system[5].

Polychlorinated biphenyls (PCBs) are mixtures of up to 209 individual chlorinated compounds, or congeners. The chemical was used as a coolant and as a lubricant in transformers, capacitors, and other electrical equipment before being banned in 1977. Some workers exposed to PCBs developed cancer of the liver and biliary tract. As a result, PCBs have been determined to be probably carcinogenic to humans[12]. People exposed to PCBs have skin ailments such as acne and rashes. Exposed people also have changes in blood and urine which indicates possible liver damage[5].

These nine chemicals are slated to banned from the world market because of their potential to cause great harm to humans. The Annex C chemicals dioxins, furans, hexachlorobenzene, and PCBs cannot be banned outright because they are unintended byproducts of incomplete thermal processes involving chlorine and organic matter from industrial sources such as waste incinerators, cement kilns, pulp production using elemental chlorine or chemicals generating elemental chlorine for bleaching, waste oil refineries, crematoria, and motor vehicles, particularly those using leaded gasoline. These chemicals are also created from copper production, zinc production, and aluminum production and from sinter plants in the iron and steel industry.

Dioxins and furans have the potential to be harmful to humans. Furans and dioxins are a structurally related family of over 210 compounds, the most toxic of which is 2,3,7,8-TCDD. TCDD has been determined to reasonably be anticipated to cause cancer due to the fact that animals show an increased risk of cancer after being exposed to the chemical[12]. Exposed animals also suffer from reproductive difficulties. Rhesus monkeys developed endometriosis after chronic low dose exposure[13] and increased rates of spontaneous abortions[14], while rats had decreased spermatogenesis[13]. Human exposure to TCDD leads to an increase in the rates of breast, endometrial and testicular cancer[15].

Since dioxins, furans, PCBs, and hexachlorobenzene are produced inadvertently, the goal of the Stockholm plan is to reduce the total emissions of these chemicals into the air by changing the management practices in the industrial factories that generate these emissions. Such practices would include using less hazardous substances, using low-waste technology, promoting the recovery and recycling of wastes and of substances created and used, and avoiding the use of elemental chlorine or elemental chlorine-generating chemicals for bleaching.

The Annex B chemical DDT is treated differently than the other 11 POPs. Even though DDT is also a persistent organic pollutant, it will not be banned due to its role as a main component of many anti-malaria programs across the globe.   Malaria afflicts 300 million people annually, killing between 1.1 and 2.5 million of them. Over 95% of these deaths occur in Africa. Children are most likely to die from malaria since they have not yet built up an immunity to the disease. Adults who were afflicted with malaria as children become sick if re-infected with malaria but will not usually die from the disease. Some economic analysts have put the economic burden of malaria in Africa at 0.6-1.0% of the gross domestic product (GDP). Some malaria stricken countries fare worse than others. Estimates place the income levels of countries with severe malaria at only 33% of countries without malaria[1]. Malaria's impact on the world economy explains why DDT was given seemingly preferential treatment over the other persistent organic pollutants in the POPs treaty.

For this reason, DDT should be examined more closely than the other 11 POPs. Twenty-five malaria stricken countries have thus far requested an exemption to use DDT (table 2)[1], and the countries China, Korea, India, and Russia have requested exemptions to produce DDT which means that DDT will still have a large presence throughout the world.

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[1] Severe malaria is defined as having a malaria index of greater than 0.5. The malaria index for a country is the fraction of the population living in areas of high malaria in 1994 multiplied by the fraction of malaria cases in 1990 that are of the *P. falciparum* mosquito species. (World Health Organization 1992)

Table 2: A Listing of Countries that Requested an Exemption to Use DDT Before the Close of the Fifth Session of the POPs Treaty Negotiations in South Africa (December 2000).

Country	
Algeria	Mozambique
Bangladesh	Panama
China	Papua New Guinea
Comoros	Republic of Korea
Costa Rica	Russian Federation
Ecuador	Saudi Arabia
Ethiopia	South Africa
India	Sudan
Kenya	Swaziland
Madagascar	Uganda
Malawi	United Republic of Tanzania
Mauritius	Yemen
Morocco	Zambia

DDT does have benefits. Its toxicity to mosquitoes, persistence in the environment, and cheapness has made it the most effective antimalarial treatment thus far. However, its drawbacks cannot be ignored. DDT is an animal carcinogen and a possible human carcinogen[12]. Some studies have linked its metabolite DDE with an increase in the risk of breast cancer[16,17]. As an endocrine disruptor, which is a synthetic chemical that either mimics or blocks hormones and disrupts the body's normal functions when absorbed into the body, DDT can alter the body's endocrine balance. As a lipophilic compound, DDT passes from mother to child through breast milk.

Endocrine disruptors disrupt the body's normal functions by altering the production, metabolism, release or elimination of essential hormones. Endocrine disruptors are lipophilic chemicals that are persistent in the environment. Once absorbed by the body, lipophilic chemicals remain in the fatty tissues instead of being eliminated. The chemicals either diffuse across cell membranes to bind to intracellular receptors or are distributed to a storage site. Over time, these chemicals bioaccumulate, which can cause great harm to the body. If the organism undergoes rapid lipid loss, the storage sites release the lipophilic chemicals which will then circulate throughout the body and then possibly attach to target molecules.

Endocrine disruptors are especially harmful to certain species. Many fish, amphibians, and reptiles exhibit environmental sex determination. In other words, environmental factors such as temperature can affect the sex of an undifferentiated embryo. Endocrine disruptors have been shown to cause feminization and masculinization of developing embryos of fish, amphibians, and reptiles. For instance, when red-eared turtle embryos that are in an environment that is at a male-producing temperature are exposed to estradiol during the sex determination period, phenotypically female turtles are produced[18].

While DDT is not made in the United States anymore, it is still being produced in the countries China and India. As a result DDT may be released into the atmosphere. DDT and its metabolites, dichlorodiphenyldichloroethylene (DDE) and dichlorodiphenyl-dichloroethane (DDD), also enter the air when they evaporate from contaminated water and soil. DDT breaks down quickly in the air. Half of the DDT released into the air breaks down within two days. However, the break down process greatly slows when DDT is released into the soil. DDT attaches to the soil, and it has the potential to last in the soil for hundreds of years[5]. When DDT persists in the environment, it does not remain in the form of DDT. Microorganisms break DDT down into DDD and DDE, with

DDE being the most prevalent breakdown product. The length of time that DDT lasts in the soil depends upon properties such as temperature, soil type, and soil porosity. In temperate areas, the half life of DDT, DDD, and DDE is usually about 5 years but in some cases it can remain for 20 to 30 years[5].

When studies have been performed to examine the effect of DDT on the human environment, the researchers are usually examining the effects of DDE on the human body. It has been shown that DDE has carcinogenic effects on lab animals. The chemical causes liver cancer in rodents[19]. As for wildlife, the birth rates of birds and reptiles decreased due to eggshell thinning. DDE causes the inhibition of prostaglandin synthesis in the shell gland which causes the retardation of calcium deposition around the eggshell membranes[20,21].

DDE acts as an antiandrogen when administered to rats *in utero*, producing teratogenic effects. The endocrine system is composed of hormones, glands, which release the hormones, and receptors, which capture the hormones. One of the functions of the endocrine system is to regulate sexual maturation. The hormones that are released into the body accomplish this goal. In humans, the male configuration develops with androgenic hormones, while the female configuration develops with estrogens. Antiandrogens, like DDE, serve disrupt the endocrine balance. Since the endocrine system regulates sexual maturation, a disturbance in the endocrine balance may cause feminizing effects in males[22].

When DDE is administered at 100 mg/kg body weight per day to Long-Evans Hooded and Sprague-Dawley male rats, it reduces anogenital distance (AGD), reduces the weight of androgen-dependent tissue, such as the prostate, and causes the retention of nipples[23]. The Sprague-Dawley rats also suffered from hypospadias, which is the abnormal positioning of the meatus, the opening from which urine passes along the urethra canal. You et al. also found that DDE induced antiandrogenic effects on AGD and areola development in the Long-Evans Hooded and Sprague-Dawley male rats[24]. In addition, there was an increased incidence of chronic suppurative prostatitis[25], which is persistent relapsing pain or discomfort in the pelvic region.

The administration of DDE or DDT during gestation and/or lactation produces reproductive effects in the Dutch Belted rabbit. When rabbit does were treated with DDT at 25 or 250 mmol/kg of body weight, cryptorchidism, or the failure of testicles to descend, was induced. Some atypical germs cells, which resemble carcinoma-in-situ (CIS) cells, were noted in the undescended testes[26]. CIS cells were first identified as atypical germ cells in the human testes that later developed into testicular germ tumors[23]. These findings were repeated when rabbit does were exposed weekly to DDT at 25 mg/kg of body weight from the beginning of the gestation process through six weeks post-partum, while their offspring were exposed to DDT at 10 mg/kg of body weight from post-natal weeks six through twelve[27]. This data indicates that rats and rabbits develop developmental and reproductive defects as a result to exposure to levels of DDT that for a period of time in the late 1960s to which human fetuses were legally exposed.

Alligators living in Lake Apopka showed reproductive abnormalities such as small penis, abnormal hormone levels, increasing levels of intersexed animals, and a decrease in the percentage of male offspring. These abnormalities were associated with the presence of DDE at concentrations of 5.8 ppm in the alligator eggs[28]. Regardless of the abundance of clinical experiments that show a link between DDT and developmental and reproductive effects on rats, rabbits, and wildlife, there has been conflicting evidence as to whether DDT has a harmful effect on exposed humans. A small 1980 study by Unger and Olsen examined the relationship between levels of DDE in adipose tissue and cancer risk in women[16]. Levels of DDE in adipose tissue increased with age in the women, regardless of whether the women had cancer or not. However, the mean levels of DDE that were extracted from the abdominal adipose tissue from 11 women with cancer were higher than the levels in 22 women without cancer. The levels of DDE were 5.03 parts per million (ppm) and 2.14 ppm, respectively. Due to the small sample size of this study, many people do not give much significance to the results. However, the intriguing results of this study spurred on later research on the link between DDT and DDE and the risk of breast cancer.

Mussalo-Rauhamaa et al. examined the levels of DDT and DDE in the adipose tissue of 44 women with breast cancer to the levels of DDT and DDE in postmortem tissue of 33 women who had died of accidental deaths[29]. There were no differences between the mean levels of DDT or DDE between the women with breast cancer (DDE: 0.96 ± 0.63 mg/kg fat; DDT: 0.07 ± 0.09 mg/kg fat) and the control group (DDE: 0.98 ± 0.89 mg/kg fat; DDT: 0.06 ± 0.07 mg/kg fat).

Between 1985 and 1991, Wolff et al. obtained blood samples from14,290 women who were enrolled in the New York University's Health Study[17]. Fifty-one breast cancer patients and 171 controls were matched for age at entry into the study, date of blood donations, and status of menopause. Risks were adjusted for family risk of breast cancer, lactation, and age at first full-term pregnancy, all of which have an impact on a women's risk of contracting breast cancer. The results showed that women within the highest quintile of levels of serum DDE were 3.68 times as likely to develop breast cancer as women in the lowest quintile.

This finding contrasts with the results of a study done by Krieger et al. in northern California[30]. Blood sample were taken from 57,040 women who donated blood between 1964 and 1971, a period of time in which DDT was still in use. The serums DDE levels were compared in 150 women who had breast cancer and 150 matched controls. The mean time between obtaining blood samples and the diagnosis of breast cancer was 14.2 years. There was no significant difference in the risk of developing breast cancer for women in the highest tercile for serum DDE levels compared to women in the lowest tercile.

A case study was also conducted in Mexico City to compare serum DDE and DDT levels in 141 women with breast cancer to 141 controls[31]. The mean serum levels of DDE were slightly higher in cancer cases (562.5 parts per billion (ppb)) than in controls (505.5 ppb), however, the difference was not deemed to be significant. In the case of mean serum levels of DDT, the levels were higher in controls (84.53 ppb) than in cancer cases (61.45 ppb).

In a study conducted among over 1000 women in Long Island, there was little evidence that the presence of DDT and DDE was linked to an increase in cancer risk[32]. Women in the highest quintile of lipid-adjusted serum levels had 1.20 times the risk of women in the lowest quintile. This increase was deemed by the authors to be “not significant.” In fact, other studies have failed to find a link between DDT, DDE and an increased cancer risk. Demers et al. found no association between exposure to DDE and breast cancer, but they did find a link to “an increased risk of having a large tumor and axillary-lymph-node involvement" among some cases[33]. This association can lead to "more aggressive breast tumors and a less favorable clinical course"[32]. The authors suggest additional studies examining other prognostic factors such as survival.

There are two explanations for the reason why many studies may have failed to find a link between DDT exposure and increased cancer risks. For one, most of the studies look at serum levels instead of adipose tissue levels when measuring the level of DDE. Researchers assumed that the level of organochlorines came to an equilibrium and that the concentration of the organochlorines was equal throughout the body. However, recent studies have shown that the ratio of adipose levels to serum levels is greater than one[34]. So the levels of organochlorines in the serum are lower than in the adipose tissue. The serum levels range from 80%[33] to as low as 30-60%[35, 36] of the value of adipose tissue levels.

There is a second reason studies might have failed to find a link between DDT, DDE, and increased cancer risk. Since the ban on DDT occurred, most of the public's exposure to DDT has been not through the more estrogenic parent agent that was sprayed as a pesticide, but rather through the less estrogenic DDE by way of the public's diet[37]. The significance of DDE being less estrogenic than technical DDT is that it is not as potent of a hormone mimic. DDE's ability to disrupt the body's endocrine balance is not as strong as that of DDT.

The estrogenic capacities of DDT and its metabolites have been evaluated in *in vivo* and *in vitro* assays. In *in vivo* assays, DDT has consistently shown a positive estrogenic response, while DDE has shown little or no estrogenic response[38]. In addition, studies have shown that DDT inhibits the binding of the hormone estradiol, which is responsible for regulating the menstrual cycle and estrus and secondary sex characteristics, to recombinant human endoplasmic reticulum and rodent uterine endoplasmic reticulum, while DDE shows weak binding to endoplasmic reticulum[37].

Some animals and fish can metabolize DDT to DDE, while humans can consume DDE from dietary sources and store it in their adipose tissue. However, research has shown that the human body cannot metabolize DDT to DDE. Male subjects were fed technical DDT but were unable to metabolize the chemical to DDE[39]. The authors of the study suggested that most of the DDE stored in the adipose tissue of humans is via dietary consumption rather than by exposure to the pesticide DDT (and subsequent metabolism of DDT to DDE by the body).

These findings may help to explain why North American and European studies have been slow to find a link between DDT, DDE and breast cancer risk. In North America and in Europe, DDT has been banned for decades so the population is not exposed to the chemical in its most potent form. The public has been exposed to DDE due to its persistence in the environment, since DDE found its way into the food supply via the tissue of animals and fish that are a part of the food chain.

Based on the harm that DDT can potentially cause to humans, the ratification of this treaty will have a tremendous impact on the world. Identifying the variables that influence a country to ratify the POPs treaty may provide insight into the motivation of a nation to allow the use of DDT in malaria control programs, especially given the uncertainty as to whether DDT harms exposed persons. Are malaria-stricken countries more willing to ratify the treaty than countries with no history of malaria? Do countries that earmark a larger than average percentage of their GDP to public health more likely to be ratifiers than nations that do not provide adequate funding to their public health sector? The rationale behind this question is that nations with fully developed health care systems are very much aware of the devastating effect that malaria has on the world. With between 1.1 and 2.5 million malaria deaths each year, public health conscious nations may have chosen to ratify the POPs treaty to ensure that DDT will remain available for the foreseeable future, even though there is a good chance that DDT can prove harmful to people who are exposed to it.

This chapter has provided a synopsis of the Stockholm Convention. In addition, it presented an overview of related research concerning the risks to human health posed by these chemicals. In Chapter 3, I will discuss the data and methods to be applied in this analysis.

CHAPTER 3. DATA AND METHODS

The issue of concern is whether certain variables may influence a nation's decision to ratify the Stockholm convention. In order to determine the factors that are associated with that decision, economic, quality of life, and political indicators were examined (table 3). The table also lists the sources for the data. Statistical Product and Service Solutions (SPSS version 11.5) allows variable titles to have a maximum of 8 characters each. Since the majority of the indicator names are longer than 8 characters long, table 3 also lists the SPSS variables names and the variables that they represent. One hundred sixty-five countries were evaluated using SPSS version 11.5 to determine which of the variables are significantly correlated with nations' deciding to ratify the Stockholm Convention. The data was analyzed using Pearson correlation, a comparison-of-means test, and factor analysis.

The dependent variable used in the analyses was whether a country had ratified the treaty (as of November 2004). The information for this dichotomous variable was obtained from the International POPs Elimination Network. Dichotomous variables have only two possible values—yes or no, or 0 or 1.

A second dichotomous variable also factored into the analysis is whether a country has a history of malaria. The information for this was taken from the Committee to Advise on Tropical Medicine and Travel (CATMAT) 1997. Countries with a history of endemic malaria or malaria epidemics are listed in table 4[40]. These nations are all of those in which malaria cases are still being currently reported.

Table 3: Variables Constructed for SPSS Analysis.

Type of indicator	Indicator	Source	Coded	SPSS Variable Name
dependent variable	treaty ratification	Committee to Advise on Tropical Medicine and Travel (1997)	0=no, 1=yes	ratifier
Economic (independent variables)	GDP per capita	World Bank (1998) and United Nations Population Division (2002)	dollars	gdp
	distribution of GDP into the agriculture sector	World Bank (1998), International Standard Industrial Classification divisions 1-5	percent	agrdist
Geographical (independent variables)	location in asia	World Bank, World Resources Institute, Food and Agriculture Organization of the United Nations	0=no, 1=yes	asia
	location in europe	World Bank, World Resources Institute, Food and Agriculture Organization of the United Nations	0=no, 1=yes	europe
	location in the middle east & north africa	World Bank, World Resources Institute, Food and Agriculture Organization of the United Nations	0=no, 1=yes	mideast
	location in sub-saharan africa	World Bank, World Resources Institute, Food and Agriculture Organization of the United Nations	0=no, 1=yes	subsaf
	location in north america	World Bank, World Resources Institute, Food and Agriculture Organization of the United Nations	0=no, 1=yes	n.am
	location in central america & caribbean	World Bank, World Resources Institute, Food and Agriculture Organization of the United Nations	0=no, 1=yes	c.am
	location in south america	World Bank, World Resources Institute, Food and Agriculture Organization of the United Nations	0=no, 1=yes	s.am
	location in oceania	World Bank, World Resources Institute, Food and Agriculture Organization of the United Nations	0=no, 1=yes	ocean
Health (independent variables)	history of malaria	World Bank, World Resources Institute, Food and Agriculture Organization of the United Nations	0=no, 1=yes	malaria
	% of GDP spent on public health	World Bank (1998), World Health Organzation, and United Nations Population Division (2002)	percent	pubhlth
	fertility rate	Earthtrends	children per women	fertrate
	mortality under five	United Nations Children's Fund (UNICEF) (2000)	per 1000 live births	mort_5
	life expectancy	United Nations Population Division	years	lifeexp

Table 3 continued.

Type of indicator	Indicator	Source	Coded	SPSS Variable Name
Political (independent variables)	type of government	The Polity IV Project	values range from -10 to 10	govt
Social (independent variables)	male literacy rate	United Nations Educational, Scientific, and Cultural Organization	percent	litratem
	female literacy rate	United Nations Educational, Scientific, and Cultural Organization	percent	litratef
	population density	World Resources Institute, Food and Agriculture Organization of the United Nations, and United Nation Population Division (2002)	people per square kilometer	popdens

Table 4: Countries with a History of Malaria.

Afghanistan	Côte d'Ivoire	Libyan Arab Janahiriya	Saudi Arabia
Algeria	Djibouti	Madagascar	Senegal
Angola	Dominican Republic	Malawi	Sierra Leone
Argentina	Ecuador	Malaysia	Solomon Islands
Azerbaijan	Egypt	Mali	Somalia
Bangladesh	El Salvador	Mauritania	South Africa
Belize	Equatorial Guinea	Mauritius	Sri Lanka (formerly Ceylon)
Benin	Eritrea	Mayotte	Sudan
Bhutan	Ethiopia	Mexico	Suriname
Bolivia	French Guiana	Morocco	Swaziland
Botswana	Gabon	Mozambique	Syrian Arab Republic
Brazil	Gambia	Myanmar	Tajikistan
Burkina Faso	Ghana	Namibia	Tanzania
Burma	Guatemala	Nepal	Thailand
Burundi	Guinea	Nicaragua	Togo
Cambodia	Guinea-Bissau	Niger	Turkey
Cameroon	Guyana	Nigeria	Uganda
Cape Verde	Haiti	Oman	United Arab Emirates
Central African Republic	Honduras	Pakistan	Vanuatu
Ceylon	India	Panama	Venezuela
Chad	Indonesia	Papua New Guinea	Viet Nam
China	Iran	Paraguay	Yemen
Colombia	Iraq	Peru	Zaire (Republic of Congo)
Comoros	Kenya	Philippines	Zambia
Congo	Lao People's Domestic Republic	Rwanda	Zimbabwe
Costa Rica	Liberia	Sao Tome and Principe	

Quality-of-life indicators were also used in the analyses. These factors are: population density, total fertility rate, mortality under five, and life expectancy. Population density was calculated by the World Resource Institute as the total population of a nation in 2002 divided by the total land area in square kilometers. The population data was provided by the United Nation Population Division, and the total land area is from the Food and Agriculture Organization of the United Nations.

Total fertility rate is defined as the number of children per woman from the period 2000 to 2005. It is an estimate of the number of children a woman will possibly have over her lifetime if current population trends within the country continue. This information was provided by Earthtrends.

Mortality under five is a measure of the number of children that die between birth and the age of 5 and is expressed per 1,000 live births. The data is taken from the year 2000 and is provided by the United Nations Children's Fund (UNICEF) Multiple Indicator Cluster Survey and Demographic and Health Surveys.

Life expectancy is the number of years a newborn is expected to live if current age-specific mortality rates continue. The data is from the period 2000 to 2005 and is provided by the United Nations Population Division.

The economic indicators that were examined are the gross domestic product (GDP) per capita, percentage of GDP spent on public health, and distribution of goods into the agriculture sector. The gross domestic product per capita is the sum of gross value of all producers in the society in addition to taxes and less any subsidies not included in the value of the products divided by the total population[41]. The GDP values are in terms of 1995 dollars and are provided by the World Bank. The population data is provided by 2002 United Nations Population Division data.

The government expenditure into the public health as a percentage of GDP is determined by 1998 data provided to the World Health Organization by the World Bank. This expenditure is the “proportion of the gross domestic product used by recurrent and capital spending from government budgets and social health insurance funds”[40].

Distribution of goods into the agriculture sector is a measure of the “percent of total output of goods and services which are a result of value added by the [agriculture] sector”[40]. The agriculture sector includes fishing and forestry. The 2002 data was provided by the International Standard Industrial Classification divisions 1-5.

The one political variable analyzed was the polity index. The polity index is a measure of how autocratic or democratic a nation is considered to be. A fully autocratic nation scores -10 while a fully democratic nations scores +10. A fully autocratic nation “sharply restricts or suppresses competitive political participation. The chief executives are chosen by an elite group and exercise power with few institutionalized constraints”[42]. A fully democratic country has “fully competitive political participation, institutionalized constraints on executive power, and guarantee of civil liberties to all citizens in their daily lives and in political participation”[40]. The polity index was provided by the Polity IV Project.

The educational variables examined are the 2002 adult literacy rates. These rates are determined for men and women separately. The literacy data was collected during national censuses and surveys and provided by the United Nations Educational, Scientific, and Cultural Organization.

The last dichotomous variable considered was geographic placement. The world has been divided into eight regions—Asia, Europe, the Middle East and North Africa, Sub-Saharan Africa, North America, Central America and the Caribbean, South America, and Oceania. The regional groupings were developed by the World Bank, the World Resources Institute, and the Food and Agriculture Organization of the United Nations (table 5)[40]. Appendix 1 contains the indicator values inputted into SPSS.

This chapter has presented an overview of the methods I will use in the analysis and an explanation of the data I compiled to answer the research questions introduced in chapter 1. The next chapter presents the results of my analyses.

Table 5: Regional Groupings of Countries

Asia	Europe	Sub-Saharan Africa	South America
Armenia	Austria	Angola	Argentina
Azerbaijan	Belarus	Benin	Bolivia
Bangladesh	Belgium	Botswana	Brazil
Bhutan	Bosnia	Burkina Faso	Chile
Cambodia	Bulgaria	Burundi	Colombia
China	Croatia	Cameroon	Ecuador
Georgia	Czech Republic	Cape Verde	French Guiana
India	Denmark	Central African Rep	Guyana
Indonesia	Estonia	Chad	Paraguay
Japan	Finland	Congo	Peru
Kazakhstan	France	Dem Rep of Congo	Suriname
Democratic Rep.	Germany	Cote d'Ivoire	Uruguay
of Korea	Greece	Djibouti	Venezuela
Republic of Korea	Hungary	Equatorial Guinea	Amer. Samoa
Kyrgyzstan	Iceland	Eritrea	
Lao	Ireland	Ethiopia	
Malaysia	Italy	Gabon	
Mongolia	Latvia	Gambia	
Myanmar	Lithuania	Ghana	
Nepal	Macedonia	Guinea-Bissau	
Pakistan	Moldova	Kenya	
Philippines	Netherlands	Lesotho	
Singapore	Norway	Liberia	
Sri Lanka	Poland	Madagascar	
Tajikistan	Portugal	Malawi	
Thailand	Romania	Mali	
Turkmenistan	Russia	Mauritania	
Uzbekistan	Serbia	Mauritius	
Viet Nam	Slovakia	Mozambique	
	Slovenia	Namibia	
	Spain	Niger	
	Sweden	Nigeria	
	Switzerland	Rwanda	
	Ukraine	Senegal	
	United Kingdom	Sierra Leone	
		Somalia	
		South Africa	
		Sudan	
		Tanzania	
		Togo	
		Uganda	
		Zambia	
		Zimbabwe	

Table 5 continued.

Middle East & North Africa	Central America & Caribbean	North America	Oceania
Afghanistan	Belize	Canada	Australia
Algeria	Costa Rica	United States	Fiji
Egypt	Cuba		New Zealand
Iran	Dominican Rep		Papua New Guinea
Iraq	El Salvador		
Israel	Guatemala		
Jordan	Haiti		
Kuwait	Honduras		
Lebanon	Jamaica		
Libya	Mexico		
Morocco	Nicaragua		
Oman	Panama		
Saudi Arabia	Trinidad and Tobago		
Syria			
Tunisia			
Turkey			
United Arab Emirates			
Yemen			

CHAPTER 4. RESULTS

The countries were divided into two groups—those that ratified the treaty and those that chose not to ratify the treaty—and a table was created that lists the mean values of the independent variables for each group (table 6). Five ratifying countries—Saint Kitts and Nevis, Tuvalu, the Cook Islands, Monaco, and Nauru—were not included in the SPSS analysis because no contextual information could be found on these countries. The variables for geographic location were omitted from this initial analysis due to the fact that their inclusion would not have shown whether countries from one region were more willing to ratify the treaty than countries from another region. Instead, the inclusion of these variables would simply have given us the percentage of all countries that lie within a given region. For example, the mean value given for "Country is in the Sub-Saharan African Region" was 0.26, which only means that 26% of the countries examined lie in Sub-Saharan Africa.

Table 6: Mean Values.

	Country ratified the treaty (0=no, 1=yes)	
	0	1
	Mean	Mean
Country has a history of malaria	1	0
Population density (2002)	167	97
Polity index (2000)	2	5
GDP per capita (2000) ($)	$4,231	$9,064
% GDP spent on public health (1998)	3.1	3.6
Distribution of goods into agriculture sector (2000)	20	16
Total fertility rate (2000-2005)	3.5	3.1
Mortality under 5 (per 1000 live births) (2000)	76	63
Life expectancy (2000)	64.2	66.3
Adult literacy rate (men) (2002)	84	82
Adult literacy rate (women) (2002)	74	72

The table gives a general profile of a group of nations that ratified the POPs treaty. Ratifiers tend to be less densely populated, have a larger GDP per capita, are more democratic, and are less invested in agriculture than countries that did not ratify the POPs treaty. In addition, ratifying countries also tend to have lower fertility rates, lower mortality rates, lower life expectancies, and lower literacy rates than non-ratifying countries.

Further analysis compares the mean values of these independent variables for the groups of ratifying nations and non-ratifying nations to worldwide averages (table 7). The average GDP per capita of ratifying nations is 39.0% higher than that of the average nation. The percentage of GDP spent on public health in ratifying nations is 5.9% higher than in the average nation. Ratifiers have 11.1% less goods distributed into the agriculture sector than the average nation. The fertility rate in ratifying nations is 6.1% lower than in the typical nation, while the mortality rates under five are 8.7% lower. Life expectancy is 1.7% higher among the ratifying nations. In addition, the adult literacy rates for men and women in ratifying countries are over 1.2% and 2.2% lower than in the typical nation, respectively.

Next, I conducted a difference-of-means test to determine whether these differences are statistically significant (table 8). When the correlation is significant at the 0.05 level, the risk is only 5% that the observed relationship between the two variables is false. What this means is that there is only a 5% chance that the two variables are not actually correlated. With a 0.01 level of significance, there is only a 1% chance that the observed relationship between the dependent and independent variable does not exist.

Table 7: Comparison of the Groups' Mean Values to World Averages.

		Country ratified the treaty (0=no, 1=yes)			
	world average	0	1	0	1
		Mean	Mean	% diff from world average	% diff from world average
GDP per capita (2000) ($)	$6,521	$4,231	$9,064	-35.1	39.0
% GDP spent on public health (1998)	3.4	3.1	3.6	-8.8	5.9
Distribution of goods into agriculture sector (2000)	18	20	16	11.1	-11.1
Total fertility rate (2000-2005)	3.3	3.5	3.1	6.1	-6.1
Mortality under 5 (per 1000 live births) (2000)	69	76	63	10.1	-8.7
Life expectancy (2000)	65.2	64.2	66.3	-1.5	1.7
Adult literacy rate (men) (2002)	83	84	82	1.2	-1.2
Adult literacy rate (women) (2002)	73.6	74	72	0.5	-2.2

The level of significance for polity index, history of malaria, and location in Asia are 0.038, 0.024, and 0.049, respectively, while the level of significance for GDP per capita and location in Oceania are 0.008 and 0.002, respectively. Thus, the groups of nations that ratified the treaty are significantly more democratic in their domestic policies and have large GDP per capita. Location in Asia and Oceania are significantly related to whether a nation ratified the treaty. In addition, history of malaria is also significantly related to treaty ratification.

Table 8: Difference of Means.

			Sum of Squares	df	Mean Square	F	Sig.
Country has a history of malaria * Country ratified the treaty	Between Groups	(Combined)	1.246	1	1.246	5.192	0.024
	Within Groups		38.876	162	0.240		
	Total		40.122	163			
Population density (2002) * Country ratified the treaty	Between Groups	(Combined)	1.908E+05	1	190751.289	0.651	0.421
	Within Groups		4.629E+07	158	292989.313		
	Total		4.648E+07	159			
Polity index (2000) * Country ratified the treaty	Between Groups	(Combined)	183.867	1	183.867	4.392	0.038
	Within Groups		5902.203	141	41.860		
	Total		6086.070	142			
GDP per capita (2000) ($) * Country ratified the treaty	Between Groups	(Combined)	8.852E+08	1	8.852E+08	7.330	0.008
	Within Groups		1.811E+10	150	1.208E+08		
	Total		1.900E+10	151			
% GDP spent on public health (1998) * Country ratified the treaty	Between Groups	(Combined)	11.409	1	11.409	2.646	0.106
	Within Groups		577.786	134	4.312		
	Total		589.194	135			
Distribution of goods into agriculture sector (2000) * Country ratified the treaty	Between Groups	(Combined)	446.028	1	446.028	1.971	0.163
	Within Groups		32364.482	143	226.325		
	Total		32810.510	144			
Total fertility rate (2000-2005) * Country ratified the treaty	Between Groups	(Combined)	5.363	1	5.363	1.527	0.218
	Within Groups		547.929	156	3.512		
	Total		553.293	157			
Mortality under 5 (per 1000 live births) (2000) * Country ratified the treaty	Between Groups	(Combined)	7261.272	1	7261.272	1.412	0.237
	Within Groups		8.282E+05	161	5143.842		
	Total		8.354E+05	162			
Life expectancy (2000) * Country ratified the treaty	Between Groups	(Combined)	186.360	1	186.360	1.277	0.260
	Within Groups		23208.953	159	145.968		
	Total		23395.313	160			
Adult literacy rate (men) (2002) * Country ratified the treaty	Between Groups	(Combined)	119.712	1	119.712	0.427	0.515
	Within Groups		33079.454	118	280.334		
	Total		33199.167	119			

Table 8 continued.

			Sum of Squares	df	Mean Square	F	Sig.
Adult literacy rate (women) (2002) * Country ratified the treaty	Between Groups	(Combined)	113.304	1	113.304	0.185	0.668
	Within Groups		72972.696	119	613.216		
	Total		73086.000	120			
Country is in the Asia region * Country ratified the treaty	Between Groups	(Combined)	0.535	1	0.535	3.940	0.049
	Within Groups		22.019	162	0.136		
	Total		22.555	163			
Country is in the Europe region * Country ratified the treaty	Between Groups	(Combined)	0.322	1	0.322	1.843	0.177
	Within Groups		28.330	162	0.175		
	Total		28.652	163			
Country is in the Middle East/North Africa region * Country ratified the treaty	Between Groups	(Combined)	0.021	1	0.021	0.200	0.655
	Within Groups		16.778	162	0.104		
	Total		16.799	163			
Country is in the Sub-Saharan Africa region * Country ratified the treaty	Between Groups	(Combined)	0.001	1	0.001	0.004	0.947
	Within Groups		31.725	162	0.196		
	Total		31.726	163			
Country is in the North America region * Country ratified the treaty	Between Groups	(Combined)	0.000	1	0.000	0.007	0.931
	Within Groups		1.976	162	0.012		
	Total		1.976	163			
Country is in the Central America/Caribbean region * Country ratified the treaty	Between Groups	(Combined)	0.006	1	0.006	0.072	0.789
	Within Groups		14.433	162	0.089		
	Total		14.439	163			
Country is in the South America region * Country ratified the treaty	Between Groups	(Combined)	0.065	1	0.065	0.958	0.329
	Within Groups		11.057	162	0.068		
	Total		11.122	163			
Country is in the Oceania region * Country ratified the treaty	Between Groups	(Combined)	0.441	1	0.441	9.964	0.002
	Within Groups		7.169	162	0.044		
	Total		7.610	163			

Pearson's correlation is an appropriate statistical procedure when trying to determine the linear relationship between two variables. Since the goal is to determine how closely the variables are related, without regard to the ranking of such variables, the data was correlated using the Pearson method (table 9). Pearson provides actual data values instead of ordinal rankings. Whether the country ratified the treaty was the dependent variable, while the other 20 variables are independent variables.

Three of the independent variables—history of malaria, polity index, and location in Asia—have one asterisk, while GDP per capita and location in Oceania have a double asterisk[2]. A history of malaria has a 0.03 level of significance with ratification of the Stockholm treaty. The polity index is has a 0.038 level of significance and the location in Asia has a 0.049 level of significance. Location in Oceania has a level of significance of 0.002, while GDP per capita has a less than 0.001 level of significance.

Examining the Pearson correlation coefficient for each independent variable will allow us to determine whether the relationship between the dependent variable and the independent variable is an inverse one or a positive one. The Pearson's correlation coefficient ranges from +1.0 to -1.0. A coefficient value of +1.0 denotes a perfectly positive correlation between two variables, while a coefficient value of -1.0 denotes a perfectly negative correlation between two variables. Only six of the 20 independent variables have a positive correlation with the dependent variable. Those variables are GDP per capita, polity index, percentage of GDP spent on public health, life expectancy, and location in Asia and Oceania. The rest of the variables have an inverse relationship with the dependent variable.

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[2] A single asterisk indicates that the correlation is significant at the 0.05 level, while a double asterisk denotes the correlation being significant at the 0.01 level.

Table 9: Pearson's correlation.

		Country ratified the treaty	Country has a history of malaria
Country has a history of malaria	Pearson Correlation	-.170*	1
	Sig. (2-tailed)	0.030	.
	N	164	164
Country ratified the treaty	Pearson Correlation	1	-.176*
	Sig. (2-tailed)	.	.024
	N	164	164
Population density (2002)	Pearson Correlation	-0.064	-.122
	Sig. (2-tailed)	0.421	0.126
	N	160	160
Polity index (2000)	Pearson Correlation	0.174*	-.392**
	Sig. (2-tailed)	0.038	0.000
	N	143	143
GDP per capita (2000) ($)	Pearson Correlation	0.407**	-.521**
	Sig. (2-tailed)	0.000	0.000
	N	152	152
% GDP spent on public health (1998)	Pearson Correlation	0.145	-.604**
	Sig. (2-tailed)	0.093	0.000
	N	136	136
Distribution of goods into agriculture sector (2000)	Pearson Correlation	-0.138	.469**
	Sig. (2-tailed)	0.097	0.000
	N	145	145
Total fertility rate (2000-2005)	Pearson Correlation	-0.098	-.663**
	Sig. (2-tailed)	0.218	0.000
	N	158	158
Mortality under 5 (per 1000 live births) (2000)	Pearson Correlation	-0.108	.565**
	Sig. (2-tailed)	0.170	0.000
	N	163	163
Life expectancy (2000)	Pearson Correlation	0.115	-.597**
	Sig. (2-tailed)	0.148	0.000
	N	161	161
Adult literacy rate (men) (2002)	Pearson Correlation	-0.060	-.492**
	Sig. (2-tailed)	0.515	0.000
	N	120	120
Adult literacy rate (women) (2002)	Pearson Correlation	-0.039	-.547**
	Sig. (2-tailed)	0.668	0.000
	N	121	121
Country is in the Asia region	Pearson Correlation	-0.154*	.051
	Sig. (2-tailed)	0.049	0.519
	N	164	164

Table 9 continued.

		Country ratified the treaty	Country has a history of malaria
Country is in the Europe region	Pearson Correlation	0.106	-.625**
	Sig. (2-tailed)	0.177	0.000
	N	164	164
Country is in the Middle East/North Africa region	Pearson Correlation	-0.035	.081
	Sig. (2-tailed)	0.655	0.301
	N	164	164
Country is in the Sub-Saharan Africa region	Pearson Correlation	-0.005	.458**
	Sig. (2-tailed)	0.947	0.000
	N	164	164
Country is in the North America region	Pearson Correlation	.007	-0.129
	Sig. (2-tailed)	0.931	0.100
	N	164	164
Country is in the Central America/Caribbean region	Pearson Correlation	-0.021	.034
	Sig. (2-tailed)	0.789	0.661
	N	164	164
Country is in the South America region	Pearson Correlation	-0.077	.195*
	Sig. (2-tailed)	0.329	0.012
	N	164	164
Country is in the Oceania region	Pearson Correlation	0.241**	-.148
	Sig. (2-tailed)	0.002	0.059
	N	164	164

Factor analysis was also performed on the data. Factor analysis is a technique of analyzing the correlations between a number of variables by reducing them to a smaller number of dimensions called factors. A correlation is determined between each of the original variables with the each factor. In addition, factor analysis is used to determine the original variables' relationships with each other. The dichotomous independent variables were not analyzed by factor analysis. The analysis performed on the remaining independent variables extracted two factors (table 10). The eigenvalue greater than 1.0 rule states that factors are only important if the eigenvalues are greater than 1.0. Components 1 and 2 have eigenvalues of 5.565 and 1.463. These results mean that the ten original variables can be reduced to 2 factors, or new variables. Table 10 shows that these two components account for over 70% of the variance in the original variables, while the other eight components account for the remaining percentage of variance. A scree plot is used to display this information graphically (figure 1).

Table 10: Total Variance Explained.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumul. %	Total	% of Variance	Cumul. %
1	5.565	55.652	55.652	5.565	55.652	55.652	5.146	51.464	51.464
2	1.463	14.631	70.283	1.463	14.631	70.283	1.882	18.820	70.283
3	0.997	9.971	80.254						
4	0.572	5.717	85.971						
5	0.476	4.759	90.730						
6	0.421	4.206	94.936						
7	0.247	2.472	97.408						
8	0.151	1.511	98.919						
9	0.071	0.714	99.633						
10	0.037	0.367	100.000						

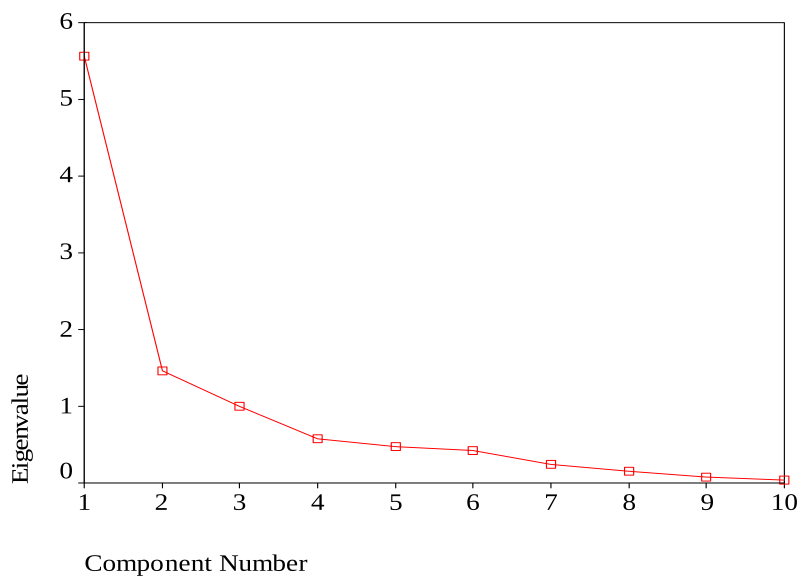

Figure 1: Scree Plot.

The component matrix shows the 10 original variables and their relationships with the two factors (table 11). Polity index, GDP per capita, percentage of GDP spent on public health, life expectancy, and adult literacy rates are associated with factor 1, while population density, distribution of goods into agriculture sector, total fertility rate, and mortality rate under five are associated with factor 2.

Table 11: Component matrix.

	Component	
	1	2
Population density (2002)	0.191	0.913
Polity index	0.457	-0.297
GDP per capita (2000) ($)	0.609	0.596
% GDP spent on public health (1998)	0.581	-0.369
Distribution of goods into agriculture sector (2000)	-0.779	-0.084
Total fertility rate (2000-2005)	-0.917	0.036
Mortality under 5 (per 1000 live births) (2000)	-0.934	0.014
Life expectancy (2000)	0.859	0.049
Adult literacy rate (men) (2002)	0.863	-0.120
Adult literacy rate (women) (2002)	0.899	-0.160

Discussion of Findings.

Using the "Comparing the means" option in SPSS between the nations that ratified the treaty and those that did not allows us to determine the statistical significance in these differences. According to the analysis, five independent variables exhibit at least a significant correlation to the dependent variable when the dependent variable is treaty ratification. A significance level of less than 0.05 indicates that there is a less than 5% chance that the observed correlation between two variables does not exist. Having a significance level of less than 0.01 indicates that an extremely significant correlation exists between two variables, which is what occurs in the case of GDP per capita and location in Oceania.

GDP per capita has a level of significance of 0.008, and location in Oceania has a level of significance of 0.002. For these two variables, there is a 0.8% and 0.2% chance, respectively, that the observed correlation between these variables and the dependent variable does not exist. Given these extremely low percentages, there is a strong likelihood that GDP per capita and location in Oceania influence a nation's decision to ratify the POPs treaty. In addition, polity index has a significance level of 0.038, location in Asia has a significance level of 0.049, and history of malaria has a significance level of 0.024. In reality, there is a strong likelihood that these factors also influence a nation's decision to ratify the treaty, although the influence is not as strong as with GDP and location within the Oceania region.

According to the Pearson correlation, five of the independent variables exhibit significant correlation to the dependent variable. History of malaria, polity index, GDP per capita, location in Oceania, and location in Asia are all significantly correlated to whether a nation ratified the Stockholm treaty. The polity index has a 0.038 level of significance, history of malaria has a 0.030 level of significance, and location in Asia has a 0.049 level of significance of correlation with treaty ratification. For these three variables there is a less than 3.8% chance, 3% chance and 4.9% chance, respectively, the observed correlations between these variables and whether a country ratified the treaty do not exist. The relationships between location in Oceania and GDP per capita with treaty ratification are even stronger. There is a 0.002% and less than 0.1%, respectively, the observed correlations did not exist. In fact, for GDP per capita, the true risk is 0.00002%

which indicates an extreme unlikelihood that GDP per capita is not related to a country's decision to ratify the Stockholm treaty.

A discrepancy becomes apparent when comparing the results from "Comparing the Mean" and the Pearson correlation. The values for the levels of significance differ between the two methods, although the strengths of the relationships (i.e. whether the correlation is denoted as "significant" or "extremely significant") do not differ. For example, GDP per capita has a level of significance 0.008 when comparing the means but has a 0.00002 significance level when using the Pearson correlation. Also, malaria has levels of significance of .024 and 0.030 when comparing the means and using the Pearson correlations, respectively. However, with both methods of analysis, both variables are deemed to have an extremely significant correlation to treaty ratification.

Perhaps the reason for the discrepancy in the values of the significance levels is that one-tailed tests are used during the analysis of means, while two-tailed tests are used in the Pearson correlation. Two-tailed tests have rejection regions on both sides of the mean, with each rejection region consisting of 2.5% (5% level of significance /2 = 2.5%) of the sample means, while one-tailed tests have a rejection region on only one side of the means, with the rejection region consisting of 5% of the sample means. One-tailed tests are used when comparing two quantities, which is what occurs when comparing the means between the group of countries that ratified the treaty and group of the countries that did not ratify the treaty. The Pearson correlation uses two-tailed tests because the observed values for each variable can be either above or below the mean and we need a method that accommodates this possibility.

Examining the Pearson correlation coefficient can determine whether the relationships between the variables are linear or nonlinear and whether the relationships are positive or inverse. Three of the five variables that are significantly correlated to a country's decision to ratify also have positive relationships with this variable. The Pearson correlation coefficients for polity index, GDP per capita, and location in Oceania are 0.174, 0.407 and 0.241, respectively. Positive coefficients indicate that the relationships between these variables are positive. If polity index or GDP per capita within a nation increases, then so does the chance that the nation will ratify the treaty. Location in Oceania also means that a nation is more willing to ratify the treaty.

The Pearson correlation coefficient for a history of malaria and treaty ratification is -0.176 and for location in Asia and treaty ratification is -0.154, which indicates an inverse relationship between the two independent variables with treaty ratification. In the case of history of malaria, this inverse relationship at first glance appears to be counter-intuitive. Why would countries with a history of malaria be less likely to ratify the treaty? It would make sense that countries that suffer from malaria would be more willing than non-malaria stricken countries to ratify a treaty that sets up guidelines for DDT use in malaria control programs. A comparison of the variables that are correlated to treaty ratification and whether a country has a history of malaria explain this inconsistency.

As discussed previously, countries that ratify the treaty are significantly and positively correlated to GDP per capita and polity index. Using the Pearson correlation method while letting history of malaria be the dependent variable yields significantly different results. In this situation, distribution of goods into agriculture sector, fertility rate, mortality under five, and location in Sub-Saharan Africa and South America are positively and significantly correlated to a history of malaria with Pearson correlation coefficients of 0.469, 0.663, 0.565, 0.458, and 0.195, respectively. The levels of significance for these variables are 0.001 for all the variables except for location in South America which has a significance level of 0.012.

Variables that are significantly and positively correlated to a history of malaria are inversely related to treaty ratification. Eight variables are inversely and significantly correlated to a history of malaria, and two of these variables are GDP per capita and polity index. If a nation has high levels of GDP per capita and in the polity index, there is a strong likelihood that this nation is not afflicted by malaria. This is not to say that a low GDP per capita or an autocratic government causes a country to be stricken by malaria, but there is a strong relationship between these variables. In fact, one could argue that having a history of malaria could cause a country to have a low GDP. If a large portion of the workforce is sick with malaria, then the people cannot do their part to add to the national economy.

This analysis explains why ratification of the Stockholm treaty is inversely related to a history of malaria. Perhaps a nation's wealth and level of democracy is more important in terms of ratifying the POPs treaty than whether or not the country has a history of malaria.

The Pearson correlation method can also be used to determine whether variables have linear or nonlinear relationships. A perfectly linear relationship would be denoted with a Pearson correlation coefficient of 1.0 or -1.0, and a nonlinear relationship would have a coefficient value near zero. When treaty ratification is the dependent variable, the largest coefficient is 0.216 (for GDP per capita). In fact, all but four of the independent variables have coefficients of less than 0.150. This information strongly suggests that the relationship between the independent variables and whether a country ratified the treaty is nonlinear.

Factor analysis is used to reduce the number of variables being examined into a smaller and more manageable number of components called factors. It is also used to determine the correlation between the original variables and the factors. An examination of the Total Variance Explained table reveals that two factors account for over 70% of the percentage of variance found within the independent variables that were analyzed, which is the reason why the component matrix only shows two components. The original variables can be reduced quite easily into two factors. Factor one explained 55.7% of the variance in the original variables, while factor two explained 14.9% of the variance.

The component matrix describes the relationship that the original variables have with the two factors. Life expectancy, adult male literacy rate, and adult female literacy rates have very high factor loadings of 0.86, 0.86, and 0.90, respectively, on Factor 1, while GDP per capita, percentage of GDP spent on public health, and polity index have smaller factor loadings of 0.61, 0.58, and 0.46, respectively, on Factor 2. Mortality under five, total fertility rate, and distribution of goods into agriculture sector have large negative factor loadings of -0.93, -0.92, and -0.78, respectively, on Factor 1, which means that these variables have a strong inverse relationship with Factor 1. Population density has a high factor loading of 0.91 on Factor 2. The component matrix shows that the original ten variables can be reduced into two variables which could be labeled Factor 1 and Population Density.

The component values shows how strongly related the original variables are to each other. Life expectancy, adult male literacy rate, adult female literacy rate, and GDP per capita have component values of 0.86, 0.86, 0.90, and 0.61, respectively, while the indicators mortality under five, total fertility rate, and distribution of goods into agriculture sector have component values of -0.93, -0.92, and -0.78, respectively. These results show that indicators such as literacy rates, GDP per capita, and life expectancy are inversely related to the variables mortality under five rate, fertility rate, and distribution of goods into the agriculture sector. Countries with high GDP per capita have higher life expectancy and literacy rates than countries with a lower GDP per capita. The countries with high GDP per capita also have lower mortality and fertility rates and are more likely to be service- or industry-based rather than agriculturally-based.

The analysis presented in table 6 offers a detailed profile of a ratifying country. A typical ratifying nation does not have a history of malaria. When comparing the values of the specified indicators in typical ratifying countries to world averages, the typical ratifying nation has a larger GDP per capita, diverts a larger amount of GDP into the public health sector, is less agriculturally based, has a higher life expectancy, and has lower fertility, mortality under five, and adult literacy rates. In comparison to the typical non-ratifying nation, the ratifying nation has a higher GDP per capita, percentage of GDP spent on public health, and life expectancy. In addition, the typical ratifying nation has a lower emphasis on agriculture, and lower total fertility, mortality under five, and adult literacy rates than the typical non-ratifying nation.

These findings indicate that GDP per capita, location in Oceania and Asia, polity index, and history of malaria are contextual attributes of a nation that are significantly associated with a nation's decision to ratify the POPs treaty. This information answers the research questions introduced in chapter 1. The nations that ratify the POPs treaty are richer than average, but countries that have a history of malaria are also less likely to ratify the treaty. No significant correlation could be found between level of education and treaty ratification or between the percentage of GDP placed into the public health sector and treaty ratification. The next chapter will consider the implications of these findings and what they reveal about the conditions under which countries are more likely to ratify such treaties.

CHAPTER 5. CONCLUSIONS AND POLICY RECOMMENDATIONS

The analysis provides insight into those contextual attributes of nations that may influence decisions of whether or not to ratify the Stockholm treaty. The findings may provide researchers with valuable information as to what type of countries are more willing to be proactive against the presence of persistent organic pollutants in the environment. Results from the correlation analysis show that some factors are strongly correlated to ratification of the POPs treaty. Having a strongly democratic government and being located in Asia are strongly linked to treaty ratification, while having a high GDP per capita is extremely significantly correlated to treaty ratification. In addition, having a history of malaria and location in Oceania are strongly inversely related to treaty ratification. This inverse relationship occurs because of the typical profile of a malaria-stricken country. Countries with a history of malaria have a low GDP per capita, are more autocratic, and have economies largely based on agriculture, which is different from the profile of a treaty ratifying country—high GDP per capita, democratic, and an economy that is not based as much in agriculture.

Future research should determine whether additional health and environmental indicators may influence treaty ratification. For example, are countries with large and developed environmental policies more willing to ratify the treaty than countries with undeveloped environmental policy programs? Are countries that finance research into malaria control more or less willing to ratify the POPs treaty? Obviously, further analysis can be performed on this topic.

One limitation of this research is that the treaty has two distinct and separate goals, which are to eliminate eleven dangerous POPs and to regulate the usage of DDT in malaria control programs. For this reason, it is impossible to know which goal caused a country to ratify the treaty. While investigating the possible elimination of POPs is fascinating, my primary interest lies in my concern in countries using DDT to combat malaria. Other alternatives do exist and while they may be more expensive, they may potentially be less harmful to the human health than DDT.

Alternatives to DDT Use in Malaria Control Programs

Anti-malarial treatment programs use a variety of other chemicals and approaches to combat malaria. In addition to DDT, treatment programs use artemisinin-based combination (ACT) therapy, synthetic pyrethroids, malathion, and insecticide-treated bednets. The elimination or reduction of larval breeding sites and better house designs are also optimal methods for controlling malaria.

During the past forty years different drugs have been the first line of treatment against malaria. Chloroquine was the standard choice in the 1960s, sulfadoxine-pyrimethamine in the 1970s, and mefloquine in the 1990s. The *Plasmodium* parasite builds up resistance which it passed on through the genes of future malaria-carrying mosquitoes. This resistance has rendered chloroquine, sulfadoxine-pyrimethamine, and mefloquine impotent.

Insecticide-treated bednets are an optimal method of controlling malaria. The treated bednets reduced mortality by 25% in Gambia[42], 33% in Kenya[43], and 17% in Ghana[44].   Mosquitoes usually bite people at night which is why the bednets are so effective. The bednets are pre-treated with a dose of 0.5g of insectide/m^2 of netting. Permethrin, alphacy-permethrin, cyfluthrin, deltamethrin, etofenprox, lambdacyhalothrin, and bifenthrin are the most suitable pyrethroids to use on the bednets.   The insecticide either repels or kills mosquitoes which come into contact with the net. Two individuals can be adequately protected with one bednet, however, the bednets must be re-treated every 6 months.

A study in Kwazulu-Natal determining the efficacy of treated bednets determined that the re-treatment rates of bednets were much higher than that of DDT sprayed homes[45]. It only takes on average 2 days to treat the nets covering 7000 people, but it would take between 2 to 3 weeks to spray these people's houses. The authors of the Kwazulu-Natal study also determined the impact of bednet usage on malaria incidence. They concluded that there was a 31% reduction in the incidence of malaria in homes using treated bednets and an 18% increase in areas sprayed with DDT[45].

The authors' explanation for these results was that bednets form a physical barrier between the mosquitoes and sleeping humans and that the mosquitoes are either repelled or killed when they try to bite the people sleeping under the nets. While this reasoning explains the reduction in the incidence of malaria in the homes using treated bednets, it does not explain why there was an increase in the areas sprayed with DDT. There could be a couple of reasons for this increase. First of all, there have been documented cases of DDT resistance which is why many people are pushing for malaria treatment programs to include options other than DDT spraying. DDT resistance has been found in regions of West Africa, Iran, Pakistan, India, Sri Lanka, Greece, Egypt, Central America, and Colombia.

Another possible reason for the increase of malaria incidence in sprayed houses is that DDT is not effective on plastered or sprayed walls. DDT can only be used on clay or cement walls or on wood and thatch. As the people in disease endemic nations become wealthier, they replace their wooden huts with Western-style homes that are plastered and painted. As a result, fewer and fewer homes are suitable for DDT spraying. In addition, DDT spraying causes discoloration of the walls of sprayed homes. Some people dislike the discoloration and choose to paint over the walls, which renders the DDT treatment useless.

The use of bednets in poor malaria-stricken regions has been severely limited due to its high cost. The nets are so expensive that only the wealthiest of families can afford them. Nation-states charge large import duties and taxes on bednets. The taxes can comprise 30 to 40 percent of the retail price of the nets. So even though bednets can reduce the risk of transmission of malaria by as much as 63 percent, they still are not in wide use. The African nations of Côte d'Ivoire, Nigeria, Tanzania, Uganda, and Zambia have either reduced or abolished the taxes and tariffs on the treated bednets.

The KwaZulu-Natal study went on to determine the cost-effectiveness of the bednets. Total costs included laboratory costs and hospital and clinic costs. Based on the efficacy data of a 31% reduction of the incidence of malaria in homes with bednets and an 18% increase in malarial incidence in DDT sprayed homes, insecticide treated bednets were cheaper per person covered (20 Rands/person/year) than house spraying (38 Rands/ person/year) [45].

Artemisinins were developed during the Vietnam War, when Chinese scientists sought to find ways to combat malaria. They were successful in using extracts from the wormwood plant to control malaria. These extracts, also known as artemisinins, are believed to interact with an enzyme called PfATP6, which regulates the level of calcium in the body by pumping it out of cells. If the pump stops working, the calcium levels rise and the cells die. Artemisinins block the action of the PfATP6 enzyme in the malaria parasites which leads to the death of the parasitic cells.

Artemisinin-based therapy is currently the best treatment for drug resistant malaria. According to the World Health Organization (WHO), artemisinin is 97% effective in treating *P. falciparum*. However the access to this therapy is limited in disease endemic countries due to its high cost. Artemisinins are ten times as expensive as the standard antimalarial drugs due to its costly and lengthy extraction process from the wormwood plant.

A new antimalarial drug was developed in 2004. The drug, OZ277/RBx11160, is a synthetic peroxide which is believed to have a similar mode-of-action as artemisinins. Since OZ is a synthetic drug it has the potential to be superior to artemisinins in terms of its effectiveness. OZ will be much cheaper to manufacture than artemisinins which are dependent on the wormwood plant.

Research Implications.

After considering the different methods of malaria control, yet another line of research becomes apparent. Further research could be performed to determine how much money is spent on research and development of the different methods of malaria control by each of the countries that ratified the POPs treaty, which could provide further insight into why a country decided to ratify the treaty. If countries are unwilling to provide monetary assistance in the fight against malaria, then they may be willing to allow DDT to be the control method of choice. Relying on DDT would be cheaper than having to invest time and resources into making alternatives to DDT more affordable to poor malaria-stricken nations.

The analysis has provided preliminary answers to the original research questions. Level of democracy and GDP per capita are significantly correlated to a nation's decision to ratify the POPs treaty. With a significance level of 0.093, percentage of GDP spent on public health is linked to treaty ratification, although the relationship is not as strong as the one with GDP and level of democracy. Counterintuitively, a history of malaria causes a nation to be less likely to ratify the POPs treaty. This information confirms that indeed, countries that are richer than average and that are more willing than average to spend their money improving their health care systems are more likely to ratify the Stockholm Treaty on Persistent Organic Pollutants. Further research can determine whether environmental policies and/or willingness to invest in malaria control programs that do not include DDT influence treaty ratification.

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APPENDIX: INDICATOR VALUES INPUTTED INTO SPSS

Country	malaria	ratifier	popdens	govt	gdp	pubhlth	agr	fert	mort5	l_exp	litratem	litratef	asia	eur	mideast	subsaf	n.am	c.am	s.am	ocean
Armenia	0	1	127	5	$980	3.1	25	1.1	30	73.4	99	98	1	0	0	0	0	0	0	0
Azerbaijan	1	1	94	-7	$506	0.9	19	1.5	105	72.2	.	.	1	0	0	0	0	0	0	0
Bangladesh	1	0	996	6	$356	1.7	25	3.6	82	60.7	50	31	1	0	0	0	0	0	0	0
Bhutan	1	0	47	-8	$205	3.2	33	5.1	100	63.2	.	.	1	0	0	0	0	0	0	0
Cambodia	1	0	76	2	$272	0.6	37	4.8	135	56.2	81	59	1	0	0	0	0	0	0	0
China	1	1	135	-7	$816	2	16	1.8	40	71.2	93	80	1	0	0	0	0	0	0	0
Georgia	0	0	75	5	$476	0.9	32	1.4	29	73.6	.	.	1	0	0	0	0	0	0	0
India	1	0	317	9	$463	.	25	3	96	64.2	70	47	1	0	0	0	0	0	0	0
Indonesia	1	0	114	7	$986	0.8	17	2.3	48	67.3	93	86	1	0	0	0	0	0	0	0
Japan	0	1	338	10	$44,751	5.7	1	1.3	4	81.5	.	.	1	0	0	0	0	0	0	0
Kazakhstan	0	0	6	-4	$1,390	3.5	9	2	75	65	100	99	1	0	0	0	0	0	0	0
Dem Rep of Korea	.	.	187	-9	.	.	.	2.1	30	65.1	.	.	1	0	0	0	0	0	0	0
Republic of Korea	0	0	477	8	$13,212	2.4	5	1.5	5	75.5	99	97	1	0	0	0	0	0	0	0
Kyrgyzstan	0	0	25	-3	$884	2.9	39	2.3	63	68.6	.	.	1	0	0	0	0	0	0	0
Lao	1	0	23	-7	$450	1.2	53	4.8	105	54.5	77	56	1	0	0	0	0	0	0	0
Malaysia	1	0	70	3	$5,024	1.4	11	2.9	9	73	92	85	1	0	0	0	0	0	0	0
Mongolia	0	1	2	10	$405	.	33	2.3	78	63.9	99	98	1	0	0	0	0	0	0	0
Myanmar	1	1	72	-7	.	0.2	60	2.8	110	56.2	89	81	1	0	0	0	0	0	0	0
Nepal	1	0	164	6	$241	1.3	40	4.5	100	59.8	62	26	1	0	0	0	0	0	0	0
Pakistan	1	0	187	-6	$505	1	26	5.1	110	61	59	30	1	0	0	0	0	0	0	0
Philippines	1	1	262	8	$1,166	1.5	16	3.2	40	70	96	95	1	0	0	0	0	0	0	0
Singapore	0	0	6755	-2	$28,229	1.2	0	1.5	4	78.1	97	89	1	0	0	0	0	0	0	0
Sri Lanka	1	0	294	5	$880	1.4	20	2.1	19	72.6	95	90	1	0	0	0	0	0	0	0
Tajikistan	1	0	43	-1	$391	5.2	19	2.9	73	68	100	99	1	0	0	0	0	0	0	0
Thailand	1	0	125	9	$2,712	1.9	10	2	29	70.8	97	94	1	0	0	0	0	0	0	0
Turkmenistan	0	0	10	-9	$1,511	4.1	27	3.2	70	67.1	.	.	1	0	0	0	0	0	0	0
Uzbekistan	0	0	57	-9	$483	3.4	35	2.3	67	69.7	100	99	1	0	0	0	0	0	0	0
Viet Nam	1	1	242	-7	$357	0.8	24	2.3	39	69.2	95	91	1	0	0	0	0	0	0	0
Albania	0	1	110	5	$979	3.5	51	2.3	31	73.7	93	79	0	1	0	0	0	0	0	0
Austria	0	1	96	10	$32,886	5.8	2	1.2	5	78.5	.	.	0	1	0	0	0	0	0	0
Belarus	0	1	49	-7	$2,711	4.6	15	1.2	20	68.5	100	100	0	1	0	0	0	0	0	0

Country	malaria	ratifier	popdens	govt	gdp	pubhlth	agr	fert	mort5	l_exp	litratem	litratef	asia	eur	mideast	subsaf	n.am	c.am	s.am	ocean
Belgium	0	0	.	10	$30,838	6.1	2	1.5	6	78.8	.	.	0	1	0	0	0	0	0	0
Bosnia	0	0	81	.	$1,526	7.9	12	1.3	18	74	.	.	0	1	0	0	0	0	0	0
Bulgaria	0	1	70	8	$1,544	3.5	15	1.1	16	70.9	99	99	0	1	0	0	0	0	0	0
Croatia	0	0	82	7	$4,843	.	10	1.7	9	74.2	99	99	0	1	0	0	0	0	0	0
Czech Republic	0	1	130	10	$5,312	6.5	4	1.2	5	75.4	.	.	0	1	0	0	0	0	0	0
Denmark	0	1	124	10	$38,637	6.8	3	1.7	5	76.6	.	.	0	1	0	0	0	0	0	0
Estonia	0	0	30	6	$4,354	.	6	1.2	21	71.2	100	100	0	1	0	0	0	0	0	0
Finland	0	1	15	10	$32,056	5.3	4	1.6	5	78	.	.	0	1	0	0	0	0	0	0
France	0	1	108	9	$29,637	7.3	3	1.8	5	79	.	.	0	1	0	0	0	0	0	0
Germany	0	1	230	10	$32,676	7.8	1	1.3	5	78.2	.	.	0	1	0	0	0	0	0	0
Greece	0	0	81	10	$13,043	4.7	8	1.2	6	78.5	99	96	0	1	0	0	0	0	0	0
Hungary	0	0	106	10	$5,455	5.2	6	1.2	9	72	100	99	0	1	0	0	0	0	0	0
Iceland	0	1	3	10	$31,496	7	.	1.9	4	79.4	.	.	0	1	0	0	0	0	0	0
Ireland	0	0	55	10	$27,674	5.2	4	2	6	77	.	.	0	1	0	0	0	0	0	0
Italy	0	0	191	10	$20,943	5.5	3	1.2	6	78.7	99	98	0	1	0	0	0	0	0	0
Latvia	0	1	37	8	$2,545	4.1	4	1.1	21	71.2	100	100	0	1	0	0	0	0	0	0
Lithuania	0	0	56	10	$2,055	4.9	8	1.2	21	72.7	100	100	0	1	0	0	0	0	0	0
Macedonia	0	0	80	6	$2,526	5.3	12	1.5	26	73.6	.	.	0	1	0	0	0	0	0	0
Moldova	0	0	126	7	$634	4.3	28	1.4	33	66.6	100	99	0	1	0	0	0	0	0	0
Netherlands	0	1	385	10	$31,074	6	3	1.5	5	78.3	.	.	0	1	0	0	0	0	0	0
Norway	0	1	14	10	$38,141	7.1	2	1.7	4	78.9	.	.	0	1	0	0	0	0	0	0
Poland	0	0	119	9	$4,228	4.2	4	1.3	10	73.9	100	100	0	1	0	0	0	0	0	0
Portugal	0	1	109	10	$12,784	5.1	4	1.5	6	76.2	95	91	0	1	0	0	0	0	0	0
Romania	0	1	94	8	$1,460	3.1	13	1.3	22	69.8	99	98	0	1	0	0	0	0	0	0
Russia	0	0	8	7	$2,456	.	7	1.1	22	66	100	100	0	1	0	0	0	0	0	0
Serbia	0	0	109	7	$1,250	.	.	1.6	20	73.2	.	100	0	1	0	0	0	0	0	0
Slovakia	0	1	110	9	$4,162	5.7	4	1.3	9	73.7	.	.	0	1	0	0	0	0	0	0
Slovenia	0	1	98	10	$11,660	6.7	3	1.1	5	76.1	100	100	0	1	0	0	0	0	0	0
Spain	0	1	79	10	$17,599	5.4	4	1.1	5	78.8	99	97	0	1	0	0	0	0	0	0
Sweden	0	1	20	10	$31,301	6.6	2	1.3	4	80.1	.	.	0	1	0	0	0	0	0	0
Switzerland	0	1	174	10	$46,799	7.6	2	1.4	4	79.1	.	.	0	1	0	0	0	0	0	0
Ukraine	0	0	81	7	$895	3.6	14	1.1	21	68.1	100	100	0	1	0	0	0	0	0	0

Country	malaria	ratifier	popdens	govt	gdp	pubhlth	agr	fert	mort5	l_exp	litratem	litratef	asia	eur	mideast	subsaf	n.am	c.am	s.am	ocean
United Kingdom	0	0	246	10	$21,785	5.7	1	1.6	6	78.2	.	.	0	1	0	0	0	0	0	0
Afghanistan	1	0	36	-7	.	.	.	6.8	257	43.2	.	.	0	0	1	0	0	0	0	0
Algeria	1	0	13	-3	$1,612	2.6	9	2.8	65	70.3	78	60	0	0	1	0	0	0	0	0
Egypt	1	1	70	-6	$1,155	.	17	2.9	43	68.3	68	46	0	0	1	0	0	0	0	0
Iran	1	0	44	3	$1,493	1.7	19	2.8	44	69.7	85	71	0	0	1	0	0	0	0	0
Iraq	1	0	55	-9	.	3.8	.	4.8	130	64.9	.	.	0	0	1	0	0	0	0	0
Israel	0	0	299	10	$17,612	6	.	2.7	6	79.2	97	93	0	0	1	0	0	0	0	0
Jordan	0	1	58	-2	$1,608	3.6	2	4.3	34	71	96	86	0	0	1	0	0	0	0	0
Kuwait	0	0	114	-7	$14,041	.	.	2.7	10	76.5	85	81	0	0	1	0	0	0	0	0
Lebanon	0	1	347	.	$3,578	2.2	12	2.2	32	73.5	93	82	0	0	1	0	0	0	0	0
Libya	1	0	3	-7	.	.	.	3.3	20	70.9	92	71	0	0	1	0	0	0	0	0
Morocco	1	1	69	-6	$1,316	1.2	14	3	46	68.7	63	38	0	0	1	0	0	0	0	0
Oman	1	0	9	-9	.	2.9	.	5.5	14	71.5	82	65	0	0	1	0	0	0	0	0
Saudi Arabia	1	0	10	-10	$6,853	.	7	5.5	29	72.2	84	70	0	0	1	0	0	0	0	0
Syria	1	0	92	-7	$839	0.9	24	3.7	29	71.8	89	63	0	0	1	0	0	0	0	0
Tunisia	0	1	59	-3	$2,497	2.2	12	2.1	28	70.9	83	63	0	0	1	0	0	0	0	0
Turkey	1	0	88	7	$3,070	3.5	16	2.3	45	70.5	94	78	0	0	1	0	0	0	0	0
United Arab Emirates	1	1	32	-8	.	0.8	.	2.9	9	75.4	76	81	0	0	1	0	0	0	0	0
Yemen	1	1	38	-2	$300	2	15	7.6	117	61.9	70	29	0	0	1	0	0	0	0	0
Angola	1	0	11	-3	$506	.	6	7.2	295	45.8	.	.	0	0	0	1	0	0	0	0
Benin	1	1	59	6	$414	1.6	38	5.7	154	54	55	26	0	0	0	1	0	0	0	0
Botswana	1	1	3	9	$4,107	2.5	4	3.9	101	36.1	76	82	0	0	0	1	0	0	0	0
Burkina Faso	1	1	45	-3	$246	1.3	35	6.8	198	48.1	36	16	0	0	0	1	0	0	0	0
Burundi	1	0	240	-1	$151	0.6	51	6.8	190	40.6	58	44	0	0	0	1	0	0	0	0
Cameroon	1	0	33	-4	$675	1.1	44	4.7	154	50	81	67	0	0	0	1	0	0	0	0
Central Africa Rep	1	0	6	6	$339	2	55	4.9	180	44.3	62	38	0	0	0	1	0	0	0	0
Chad	1	1	7	-2	$213	2.3	39	6.7	198	46.3	55	38	0	0	0	1	0	0	0	0
Congo	1	0	9	-6	$841	2	5	6.3	108	51.6	89	77	0	0	0	1	0	0	0	0
Dem Rep Congo	0	0	23	.	.	.	.	6.7	207	52.1	75	54	0	0	0	1	0	0	0	0
Cote d'Ivoire	1	1	52	4	$743	1.2	29	4.6	173	47.9	61	40	0	0	0	1	0	0	0	0
Equatorial Guinea	1	0	17	-5	$1,600	.	7	5.9	156	52	93	77	0	0	0	1	0	0	0	0
Eritrea	1	0	34	-6	$174	.	17	5.3	114	52.4	69	47	0	0	0	1	0	0	0	0

Country	malaria	ratifier	popdens	govt	gdp	pubhlth	agr	fert	mort5	l_exp	litratem	litratef	asia	eur	mideast	subsaf	n.am	c.am	s.am	ocean
Eritrea	1	0	34	-6	$174	.	17	5.3	114	52.4	69	47	0	0	0	1	0	0	0	0
Ethiopia	1	1	.	1	$118	1.7	52	6.8	174	43.3	49	34	0	0	0	1	0	0	0	0
Gabon	1	0	5	-4	$4,378	2.1	6	5.4	90	52.9	.	.	0	0	0	1	0	0	0	0
Gambia	1	0	121	-5	$371	1.9	38	4.8	128	47.1	46	32	0	0	0	1	0	0	0	0
Ghana	1	1	85	2	$413	1.8	35	4.2	102	57.2	82	66	0	0	0	1	0	0	0	0
Guinea	1	0	34	-1	$549	2.3	24	5.8	175	48.5	.	.	0	0	0	1	0	0	0	0
Guinea-Bisseau	1	0	35	6	$210	.	59	6	215	45.4	57	26	0	0	0	1	0	0	0	0
Kenya	1	1	55	-2	$322	2.4	20	4.2	120	49.3	90	79	0	0	0	1	0	0	0	0
Lesotho	0	1	68	.	$552	.	17	4.5	133	40.2	74	94	0	0	0	1	0	0	0	0
Liberia	1	1	30	0	.	.	.	6.8	235	55.6	72	39	0	0	0	1	0	0	0	0
Madagascar	1	0	29	7	$239	1.1	35	5.7	139	53.6	75	62	0	0	0	1	0	0	0	0
Malawi	1	0	100	7	$154	2.8	42	6.3	188	39.3	76	49	0	0	0	1	0	0	0	0
Mali	1	1	10	6	$275	2.1	46	7	233	52.1	38	17	0	0	0	1	0	0	0	0
Mauritania	1	0	3	-6	$496	1.4	22	6	183	52.5	52	31	0	0	0	1	0	0	0	0
Mauritius	1	1	.	.	.	.	.	.	.	.	.	.	0	0	0	1	0	0	0	0
Mozambique	1	0	24	6	$185	2.8	24	5.9	200	38	62	31	0	0	0	1	0	0	0	0
Namibia	1	0	2	6	$2,408	3.7	11	4.9	69	44.3	84	83	0	0	0	1	0	0	0	0
Niger	1	0	9	4	$203	1.2	39	8	270	46.2	25	9	0	0	0	1	0	0	0	0
Nigeria	1	1	130	4	$283	0.8	30	5.4	184	52.1	74	59	0	0	0	1	0	0	0	0
Rwanda	1	1	309	-4	$270	.	44	5.8	187	40.9	75	63	0	0	0	1	0	0	0	0
Senegal	1	1	50	8	$616	2.6	18	5.1	139	54.3	49	30	0	0	0	1	0	0	0	0
Sierra Leone	1	1	67	.	$168	0.9	47	6.5	316	40.5	.	.	0	0	0	1	0	0	0	0
Somalia	1	0	15	.	.	.	.	7.3	225	48.9	.	.	0	0	0	1	0	0	0	0
South Africa	1	1	36	9	$3,938	3.3	3	2.9	70	47.4	87	85	0	0	0	1	0	0	0	0
Sudan	1	0	13	-7	$319	.	37	4.5	108	57	71	49	0	0	0	1	0	0	0	0
Tanzania	1	0	39	2	$183	1.3	45	5	165	51.1	85	69	0	0	0	1	0	0	0	0
Togo	1	1	84	-2	$327	1.3	38	5.4	142	52.2	74	45	0	0	0	1	0	0	0	0
Uganda	1	1	103	-4	$332	1.9	42	7.1	127	46	79	59	0	0	0	1	0	0	0	0
Zambia	1	0	14	1	$380	3.6	27	5.7	202	42.2	86	74	0	0	0	1	0	0	0	0
Zimbabwe	1	0	33	-5	$621	.	18	4.5	117	42.9	94	86	0	0	0	1	0	0	0	0
Canada	0	1	3	10	$22,537	6.5	.	1.6	6	79	.	.	0	0	0	0	1	0	0	0
United States	0	0	30	10	$31,806	5.8	.	1.9	8	77.5	.	.	0	0	0	0	1	0	0	0

Country	malaria	ratifier	popdens	govt	gdp	pubhlth	agr	fert	mort5	l_exp	litratem	litratef	asia	eur	mideast	subsaf	n.am	c.am	s.am	ocean
Belize	1	0	10	.	$3,330	2.3	21	2.9	41	74.4	94	94	0	0	0	0	0	1	0	0
Costa Rica	1	0	82	10	$3,705	5.2	9	2.7	12	76.7	96	96	0	0	0	0	0	1	0	0
Cuba	0	0	102	-7	.	.	7	1.6	9	76.4	97	97	0	0	0	0	0	1	0	0
Dominican Republic	1	1	177	8	$2,062	1.9	11	2.7	48	66.9	84	84	0	0	0	0	0	1	0	0
El Salvador	1	0	310	7	$1,751	2.6	10	2.9	40	70.3	82	77	0	0	0	0	0	1	0	0
Guatemala	1	0	110	8	$1,558	2.1	23	4.4	59	65.6	77	63	0	0	0	0	0	1	0	0
Haiti	1	0	303	-2	$359	1.4	28	4	125	53.3	54	50	0	0	0	0	0	1	0	0
Honduras	1	0	30	7	$711	3.9	18	3.7	40	65.8	76	76	0	0	0	0	0	1	0	0
Jamaica	0	0	239	9	$1,825	3.1	6	2.4	20	75.7	84	91	0	0	0	0	0	1	0	0
Mexico	1	1	52	8	$3,784	2.6	4	2.5	30	73	94	90	0	0	0	0	0	1	0	0
Nicaragua	1	0	41	8	$466	8.5	32	3.8	45	69.1	67	67	0	0	0	0	0	1	0	0
Panama	1	1	39	9	$3,279	4.9	7	2.4	26	74.5	93	92	0	0	0	0	0	1	0	0
Trinidad & Tobago	0	1	255	10	$5,149	2.5	2	1.5	20	74.8	99	98	0	0	0	0	0	1	0	0
Argentina	1	0	14	8	$7,933	2.2	5	2.4	21	73.8	97	97	0	0	0	0	0	0	1	0
Bolivia	1	1	8	9	$952	4.1	22	3.9	80	63.5	93	81	0	0	0	0	0	0	1	0
Brazil	1	1	20	8	$4,624	2.9	7	2.2	38	68.3	88	88	0	0	0	0	0	0	1	0
Chile	1	0	21	9	$5,354	2.7	11	2.4	12	75.6	96	96	0	0	0	0	0	0	1	0
Colombia	1	0	38	7	$2,301	5.2	14	2.6	30	71.9	92	92	0	0	0	0	0	0	1	0
Ecuador	1	1	46	6	$1,425	1.7	10	2.8	32	70.5	94	91	0	0	0	0	0	0	1	0
Guyana	1	0	4	6	$942	4.5	35	2.3	74	62.4	99	98	0	0	0	0	0	0	1	0
Paraguay	1	1	14	7	$1,700	1.7	21	3.8	31	70.7	95	93	0	0	0	0	0	0	1	0
Peru	1	0	21	.	$2,368	2.4	8	2.6	50	69.5	95	86	0	0	0	0	0	0	1	0
Suriname	1	0	3	.	$993	.	10	2.1	33	71.1	.	.	0	0	0	0	0	0	1	0
Uruguay	0	0	19	10	$6,115	1.9	6	2.3	17	75	97	98	0	0	0	0	0	0	1	0
Venezuela	1	0	28	7	$3,300	2.6	5	2.7	23	73.3	94	93	0	0	0	0	0	0	1	0
Australia	0	1	3	10	$23,893	6	3	1.8	6	79.2	.	.	0	0	0	0	0	0	0	1
Fiji	0	1	46	.	$2,390	2.9	18	3	22	69.8	95	92	0	0	0	0	0	0	0	1
New Zealand	0	1	14	10	$17,793	6.3	.	2	6	78	.	.	0	0	0	0	0	0	0	1
Papua New Guinea	1	1	11	10	$989	2.5	26	4.3	112	57.7	72	59	0	0	0	0	0	0	0	1
Solomon Islands	1	1	17	.	$642	.	.	5.3	25	69.2	.	.	0	0	0	0	0	0	0	1
Antigua	0	1	147	.	$9,582	0.4	4	.	15	71.6	.	.	0	0	0	0	0	1	0	0

Country	malaria	ratifier	popdens	govt	gdp	pubhlth	agr	fert	mort5	l_exp	litratem	litratef	asia	eur	mideast	subsaf	n.am	c.am	s.am	ocean
Barbados	0	1	622	.	$8,267	4.5	6	1.5	14	77	.	.	0	0	0	0	0	1	0	0
Djibouti	1	1	27	.	$783	.	4	5.8	146	40.5	77	57	0	0	0	1	0	0	0	0
Kiribati	0	1	114	.	$614	11.6	.	.	70	.	.	.	0	0	0	0	0	0	0	1
Luxembourg	0	1	.	.	$56,576	5.5	1	.	5	77.8	.	.	0	1	0	0	0	0	0	0
Marshall Islands	0	1	53	.	$1,629	.	13	.	68	.	.	.	0	0	0	0	0	0	0	1
Qatar	0	1	51	.	.	3.7	.	.	16	70.8	81	84	0	0	1	0	0	0	0	0
St Lucia	0	1	238	.	$4,189	2.6	3	2.5	19	73.8	.	.	0	0	0	0	0	1	0	0
Samoa	0	1	55	.	$1,544	3.6	2	4.2	26	70.2	82	80	0	0	0	0	0	0	0	1

VITA

The author was born in Lake Charles, Louisiana, and is a graduate of the Louisiana School for the Math, Science, and the Arts. She received a bachelor of science in civil engineering from Brown University in May 2001. She is a graduate student at Louisiana State University in Baton Rouge, Louisiana, and will earn a master of science in environmental sciences in May 2005. She is currently an Engineer Intern at the Department of Transportation and Development in Baton Rouge.